Fermilab

CMS CO_2 COOLING TEST STAND

PROCESS CONTROL SYSTEM, INSTRUMENTATION, and FIELD EQUIPMENT

Location: FermiLab \ Lab C and South Clean Room

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I. Introduction

This document fulfills electrical documentation requirements set forth by the Electrical Design Standards for Electronics to be used in Experiment Apparatus at Fermilab document and EED/Infrastructure Doc. No:H011228A document published by the PPD/Electrical department.

The CMS CO_2 Cooling Test Stand is a Carbon Dioxide cooling system which is currently located in the Lab C West aisle and the Lac C South clean room at FermiLab. The aisle and clean room are both ODH class 0, and have CO_2 risk factors comparable with ODH class 0, see PPD Doc-1348 for details.

This process system has approximately 25 electronic input sensing devices and 7 output devices. Input devices include RTD's, pressure transmitters, level transmitters, thermocouples, flow switches, CO_2 monitors, and heater and pump feedback. Output devices include a motorized valve, two heaters, a variable speed motor controller, and three solenoid valves controlling three condensing units.

All electronic and electrical control system equipment is air cooled and does not require any forced air cooling or water cooling. Cabinet air vents are provided for certain devices where appropriate.

The control system equipment components are all commercially available products which are UL listed. The process control system has been designed and built following all the required rules and standards such as the NEC. All premises wiring was installed by Fermi Electrical contractors and licensed electricians.

II. Process Control System

a. Description

The CMS CO_2 Cooling Test Stand will be controlled by a Beckhoff PLC with Beckhoff supplied I/O modules networked on an Ethernet network. This PLC system will be programmed using the TwinCat engineering programming software.

Human machine Interface controls will be provided through a touch screen display as well as C-more remote panel login. The C-more screen connects to the PLC through Private Ethernet.

b. Electric Power and Circuit Protection

Sheet 1 of drawing "9213.750-EE-486150 CMS/Detectors PIXEL Control System Wiring" shows the PLC cabinet equipment layout. It also shows the AC and DC power distribution and circuit protections. All conductors are either copper or tinned copper grade. All heaters, the CO_2 pump, and the three condensing units are powered by 208VAC-3 phase power.

AC Circuit Conductor:

Min of 8 AWG downstream of 50A or less circuit protection
Min of 12 AWG downstream of 25A or less circuit protection
Min of 14 AWG downstream of 15A or less circuit protection

Min of 16 AWG downstream of 10A or less circuit protection

DC circuit Conductor AWG:

Min of 14 AWG downstream of 15A or less circuit protection
Min of 16 AWG downstream of 10A or less circuit protection
Min of 22 AWG downstream of 5A or less circuit protection

III. Field Devices and Components

a. Heater HTR210

i. Description

Heater HTR210 is a commercial 6000 watt bayonet style electrical resistance heater. This heater has an analog power control circuit for variable power control. The heater has an internal "K" thermocouple which is connected directly to a limit control device with a power disconnect relay. This limit control scheme sets the high temperature trip and shuts off the heater by mechanically disconnecting the electrical power from the heater. This limit control device will protect the heater element from destructive high heater temperatures caused by equipment malfunctions and operator errors.

ii. Electric Power and Circuit Protection

Heater 210 is powered by 208VAC 3 phase power (20 Amp panel circuit breaker). The power is fed to a 30 amp disconnect (20A fused) installed solely for the heater. The heater control box is connected to this disconnect using 10 AWG copper wire. The heater disconnect has internal 20A fuses on the heater power circuit and the control circuit. The downstream conductors are sized and rated to meet the minimum current capacity of these fuses.

b. Heater HTR506

i. Description

Heater HTR506 is a commercial 6000 watt bayonet style electrical resistance heater. This heater has an analog power control circuit for variable power control. The heater has an internal "K" thermocouple which is connected directly to a limit control device with a power disconnect relay. This limit control scheme sets the high temperature trip and shuts off the heater by mechanically disconnecting the electrical power from the heater. This limit control device will protect the heater element from destructive high heater temperatures caused by equipment malfunctions and operator errors.

ii. Electric Power and Circuit Protection

Heater 210 is powered by 208VAC 3 phase power (20 Amp panel circuit breaker). The power is fed to a 30 amp disconnect (20A fused) installed solely for the heater. The heater control box is connected to this disconnect using 10 AWG

copper wire. The heater disconnect has internal 20A fuses on the heater power circuit and the control circuit. The downstream conductors are sized and rated to meet the minimum current capacity of these fuses.

c. VFD (Variable Frequency Drive) for CO_2 Pump

i. Description

The VFD is a commercial unit designed to run a standard AC 3 phase motor at variable speeds given a standard control analog input signal. A discrete input will direct the VFD to the off or run mode. The Beckhoff PLC will monitor various CO_2 system process parameters and provide programmed interlocks and speed control from the Beckhoff PLC.

ii. Electric Power and Circuit Protection

The VFD is fed from premises power (20 Amp panel circuit breaker) with a 15A fused disconnect (Using 12 AWG wire) within sight of the VFD and motor. The VFD will be programmed with the motor data. The VFD unit itself has internal safety interlocks which shut down the pump in case of over/under current draw, or other abnormal pump conditions. This unit was recommended and supplied by the pump manufacturer to protect the pump and 3 HP pump motor.

d. CO_2 Monitoring System – Zone 1 - Lab C West Aisle

i. Description

The CO_2 monitoring system deploys a remote MSA CO_2 head in the West aisle of Lab C. The CO_2 Sensor is an MSA model A-ULTIMAX-GP-G-36-04D2-0000-100 and have a span of 0-2%. There is also an ODH style warning horn and strobe lamp located in the hallway with a sign which reads "CO_2 ALARM; EVACUATE AREA". CO_2 readings above 1.5% will trigger relays wired directly to the warning horn and strobe lamp. An alarm is also sent through FIRUS which dispatches fire department personnel to respond. The MSA electronic unit also provides a trouble relay output which is also wired to FIRUS. The trouble output is wired in a failsafe manner, such that loss of power or blown fuse to the CO2 monitor triggers a trouble alarm which is also sent through FIRUS.

All members of the Fermilab fire department conducted a walkthrough of the system and are familiar with the layout and procedures in case of an alarm. The connections to FIRUS were tested and function properly; procedures and a report on this test are in the attached document titled *CO_2 Monitoring System Test*.

The CO_2 sensor is also wired to an MSA electronic controller which provides an analog output signal wired to the Beckhoff PLC. The PLC controls a ventilation fan that pulls air out of the Lab C aisle and vents it outside. This fan activated at a CO2 reading of 0.5%, or can be turned on manually. This ventilation fan is tested daily by the PLC and flow switch.

ii. Electric Power and Circuit Protection

The MSA equipment is wired directly to its own self contained control circuitry in its own enclosure which can be seen in illustration 5. This self contained enclosure has its own power supply which is independent of the PLC control system, allowing the ODH system to function independently of the PLC control system. The power for this ODH system comes from the UPS.

e. CO_2 Monitoring System – Zone 2 – South Clean Room

i. Description

The CO_2 monitoring system deploys a remote MSA CO_2 head in the Lab C South clean room. The CO_2 Sensor is an MSA model A-ULTIMAX-GP-G-36-04D2-0000-100 and have a span of 0-2%. There is also an ODH style warning horn and strobe lamp located in the clean room with a sign which reads "CO_2 ALARM; EVACUATE AREA". CO_2 readings above 1.5% will trigger relays wired directly to the warning horn and strobe lamp. An alarm is also sent through FIRUS which dispatches fire department personnel to respond. The MSA electronic unit also provides a trouble relay output which is also wired to FIRUS. The trouble output is wired in a failsafe manner, such that loss of power or blown fuse to the CO2 monitor triggers a trouble alarm which is also sent through FIRUS.

All members of the Fermilab fire department conducted a walkthrough of the system and are familiar with the layout and procedures in case of an alarm. The connections to FIRUS were tested and function properly; procedures and a report on this test are in the attached document titled *CO_2 Monitoring System Test*.

The CO_2 sensor is also wired to an MSA electronic controller which provides an analog output signal wired to the Beckhoff PLC. The PLC controls a motorized isolation valve which in the event of a leak will close to prevent the entire contents of the system from venting into the clean room. The South clean room has a McQuay roof mounted air handling unit which runs constantly. The operation of this air handler will be verified by a flow switch mounted in the ducts..

ii. Electric Power and Circuit Protection

The MSA equipment is wired directly to its own self contained control circuitry in its own enclosure which can be seen in illustration 5. This self contained enclosure has its own power supply which is independent of the PLC control system, allowing the ODH system to function independently of the PLC control system. The power for this ODH system comes from the UPS.

f. Condensing Unit #1

i. Description

The commercial condensing unit #1 is the smallest of three units. The unit uses R-404a as a refrigerant and uses a 2 HP Copeland scroll compressor. It operates on 208VAC 3 phase power. The unit is an On/Off unit which is controlled indirectly by the Beckhoff PLC. The condensing unit turns on or off based on the pressure differential (which can be adjusted) between the high and low sides. This

pressure can be changed by opening the solenoid valve, which decreases the differential pressure and triggers the unit to turn on. The Beckhoff PLC controls the opening and closing of these solenoid valves, which would normally be wired to a thermostat and relay. Once the solenoid valves are closed the unit remains on until it has drawn the refrigerant back into the receiver, and reached its high differential pressure threshold.

ii. Electric Power and Circuit Protection

Condensing unit #1 if fed from premises 208VAC-3 phase power(30 Amp panel circuit breaker) with a 30A disconnect (fused to 20A) placed within sight of the unit. The electrical connection from the disconnect to the unit uses 12 AWG wire. The solenoid valve is located next to the unit ant operates on 208VAC-1 phase power supplied from inside the unit and controlled by the relay from the PLC which simulates a thermostat. The commercial unit is equipped with it's own over temperature fusible plug and overpressure controls.

g. Condensing Unit #2

i. Description

The commercial condensing unit #2 is the middle sized of three units. The unit uses R-404a as a refrigerant and uses a 3.5 HP Copeland scroll compressor. It operates on 208VAC 3 phase power. The unit is an On/Off unit which is controlled indirectly by the Beckhoff PLC. The condensing unit turns on or off based on the pressure differential (which can be adjusted) between the high and low sides. This pressure can be changed by opening the solenoid valve, which decreases the differential pressure and triggers the unit to turn on. The Beckhoff PLC controls the opening and closing of these solenoid valves, which would normally be wired to a thermostat and relay. Once the solenoid valves are closed the unit remains on until it has drawn the refrigerant back into the receiver, and reached its high differential pressure threshold.

ii. Electric Power and Circuit Protection

Condensing unit #2 if fed from premises 208VAC-3 phase power (30 Amp panel circuit breaker) with a 30A disconnect (fused to 20A) placed within sight of the unit. The electrical connection from the disconnect to the unit uses 12 AWG wire. The solenoid valve is located next to the unit ant operates on 208VAC-1 phase power supplied from inside the unit and controlled by the relay from the PLC which simulates a thermostat. The commercial unit is equipped with it's own over temperature fusible plug and overpressure controls.

h. Condensing Unit #3

i. Description

The commercial condensing unit #3 is the largest of the three units. The unit uses R-404a as a refrigerant and uses a 7.5 HP Copeland scroll compressor. It operates on 208VAC 3 phase power. The unit is an On/Off unit which is controlled indirectly by the Beckhoff PLC. The condensing unit turns on or off based on the pressure differential (which can be adjusted) between the high and low sides. This

pressure can be changed by opening the solenoid valve, which decreases the differential pressure and triggers the unit to turn on. The Beckhoff PLC controls the opening and closing of these solenoid valves, which would normally be wired to a thermostat and relay. Once the solenoid valves are closed the unit remains on until it has drawn the refrigerant back into the receiver, and reached its high differential pressure threshold.

ii. Electric Power and Circuit Protection

Condensing unit #3 if fed from premises 208VAC-3 phase power (45 Amp panel circuit breaker) with a 60A disconnect (fused to 40A) placed within sight of the unit. The electrical connection from the disconnect to the unit uses 8 AWG wire. The solenoid valve is located next to the unit ant operates on 208VAC-1 phase power supplied from inside the unit and controlled by the relay from the PLC which simulates a thermostat. The commercial unit is equipped with it's own over temperature fusible plug and overpressure controls.

i. Motorized Isolation Valve (EV-406)

i. Description

The motorized valve consists of a Worchester 75 series quarter turn electronic actuator attached to a Sharpe 99 series quarter turn ball valve. The valve is controlled by the PLC which switches a double pole double throw relay attached to a 24V DC power supply.

ii. Electric Power and Circuit Protection

The valve operates on 24VDC-and 2.1 Amps is listed on the unit as maximum current draw. The valve is fused with a 3 Amp fuse and is wired with 22 AWG wire.

j. U.P.S

i. Description

The control system U.P.S. is commercial 900 W unit supplied by SEPS Inc; model PW9130-1000VA/900W Tower. The U.P.S. input power is fed from a 120VAC-1 phase premises powered outlet using the U.P.S. input line cord.

ii. Electric Power and Circuit Protection

The U.P.S. is powered by its own 20A dedicated circuit and has standard outlets located on the rear of the cabinet. All relevant control system electronics, the PLC and CO_2 monitors, are plugged into the PLC outlets.

IV. References

a. Drawings

I. 9213.750-EE-486150 CMS/DETECTORS PIXEL Control System Wiring
II. 9212.750-ME-466879 CMS/DETECTORS PIXEL CMS CO_2 COOLING P&ID

b. Documents

I. Electrical Design Standards for Electronics to be used in Experiment Apparatus at Fermilab

II. EED/Infrastructure Doc. No:H011228A

III. CO_2 Hazard Engineering Note - https://ppd-docdb.fnal.gov:440/cgi-bin/ShowDocument?docid=1348